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THE

PRINCIPAL INSECT ENEMIES OF THE GRAPE.

BY

C. L. MARLATT, M. S.,
First Assistant Entomologist.

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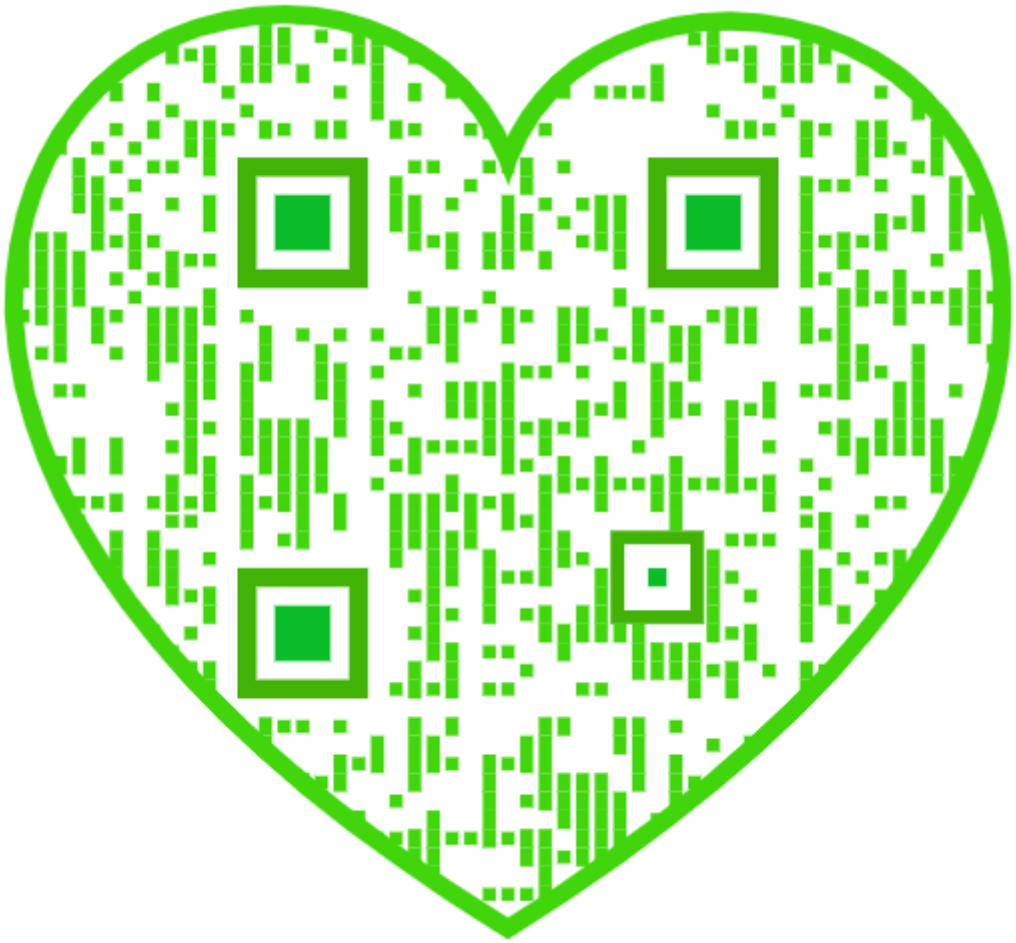

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THE PRINCIPAL INSECT ENEMIES OF THE GRAPE.

That the grape is distinctively an American plant is indicated by the fact that our indigenous wild species number nearly as many as occur in all the world besides. It is not to be wondered at, therefore, that this continent is responsible also for the chief enemies of the vine, both insect and fungous, as, for example, the grape phylloxera, which, in capacity for harm, taken the world over, outranks all other vine evils together, and such blighting fungous diseases as the two mildews and the black rot. The rapid growth of the vine industry in this country and the increasing cultivation of the less vigorous European grapes make it desirable to consider briefly, from the standpoint of remedies, its leading insect enemies.

Upward of 200 different insects have already been listed as occurring on the vine in this country, and the records of the Department alone refer to over 100 different insects. Few of these, however, are very serious enemies, being either of rare occurrence or seldom numerous, and for practical purposes the few species considered below include those of real importance. They are the grape phylloxera, the grapevine fidia, both chiefly destructive to the roots; the cane-borer, destructive particularly to the young shoots; the leaf-hopper, the flea-beetle, rose-chafer with its allies, and leaf-folder, together with hawk moths and cutworms, damaging foliage, and the grape-berry moth, the principal fruit pest.

The extent of the loss that frequently results from these insects may be understood by reference to a few instances. The phylloxera when at its worst had destroyed in France some 2,500,000 acres of vineyards, representing an annual loss in wine products of the value of $150,000,000, and the French Government had expended up to 1895 in phylloxera work over $4,500,000 and remitted taxes to the amount of $3,000,000 more. The grapevine fidia, on the authority of an Ohio correspondent, in a single season in one vineyard killed 400 out of 500 strong 5-year-old vines. The prominent leaf defoliators, as the rose-chafer and flea-beetle, frequently destroy or vastly injure the crop over large districts, and the little leaf-hopper, though rarely preventing a partial crop, is so uniformly present and widely distributed as to probably levy a heavier tribute on the grape in this country than any other insect.

These insects are, however, all amenable to successful treatment, and the loss may be very considerably limited if the proper methods of control are followed out. There are no remedies which apply generally to grape insects except the highly important considerations of clean culture and particularly the prompt collection and burning of prunings and leaves in the fall. The latter will very materially check most of the leaf insects and the cane-borer. Other remedies are particularized under each species.

THE GRAPEVINE PHYLLOXERA.

(*Phylloxera vastatrix* Planch.)

This insect has always existed on our wild vines, yet it was not until it had been introduced abroad and began to ravage the vine-

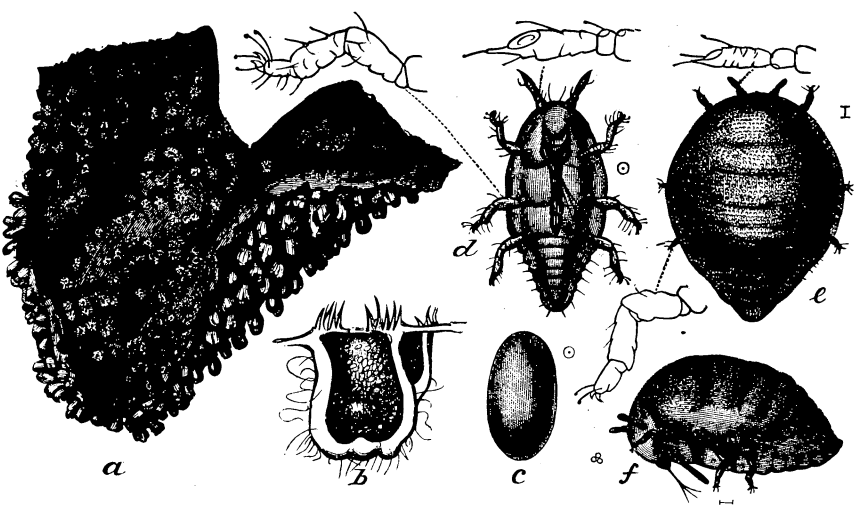

FIG. 1.—*Phylloxera vastatrix*. *a*, leaf with galls; *b*, section of gall showing mother louse at center with young clustered about; *c*, egg; *d*, larva; *e*, adult female; *f*, same from side—*a* natural size, rest much enlarged (original).

yards of the Old World that particular attention was drawn to it as a vine pest, or that anything definite was known of its habits. It appears in two destructive forms on the vine, the one forming little irregular spherical galls projecting from the underside of the leaves and the other subsisting on the roots and causing analogous enlargements or swellings. The leaf form is the noticeable one and is very common on our wild and cultivated vines. The root form is rarely seen, but is the cause of the real injury done by this insect to the vine, and while hidden and usually unrecognized, its work is so disastrous to varieties especially liable to attack that death in a few years is almost sure to result. It first produces enlargements or little galls on the rootlets. As it extends to the larger roots these

become swollen and broken, and finally the outer portion decomposes and rots, and the roots ultimately die. With the multiplication of the root lice and their extension to all parts of the root system, the vine stops growing, the leaves become sickly and yellowish, and in the last stages the phylloxera disappears altogether from the decomposed and rotting roots, and the cause of death is obscure to one not familiar with the insect. Many cases of death ascribed to drought, overbearing, winterkilling, etc., are undoubtedly due to the presence of the root louse.

The abundance of galls on the leaves is not an indication of the presence of the root louse in any numbers, but, in fact, the reverse of this is usually true; while on the other hand the destructive abundance of the lice on the roots is often, if not usually, accompanied by little, if any, appearance of the leaf form. This is particularly noticeable with the European grapes, which are very susceptible to phylloxera and rapidly succumb to it, yet rarely show leaf galls. American grapes, on the contrary, are generally very resistant to the root form, and yet are especially subject to the leaf-gall insect. Certain varieties, as the Clinton, which are most resistant to the former, are especially subject to the latter.

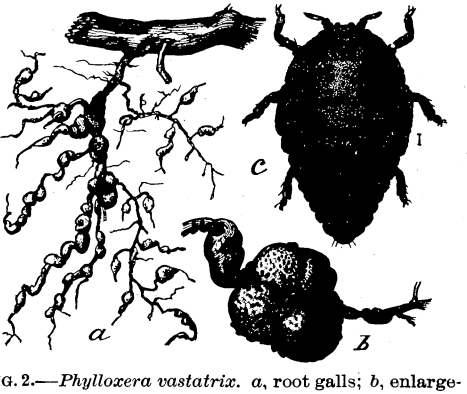

FIG. 2.—*Phylloxera vastatrix*. *a*, root galls; *b*, enlargement of same showing disposition of lice; *c*, root-gall louse—much enlarged (original).

Distribution.—The phylloxera was carried to France about 1859, on rooted American vines, and has since spread through the principal vine districts of southern Europe, extending also into Algeria and through southern Russia into the adjoining countries of Asia. It has also been carried to New Zealand and south Africa. In this country it was at first known only in the region east of the Rocky Mountains, but was soon after found in California, where, however, it is confined practically to the vine districts of the Napa and Sonoma valleys.

Life history and habits.—The life cycle of the phylloxera is a complicated one. It occurs in four forms in the following order: The leaf-gall form (*gallicola*), the root or destructive form (*radicicola*), the winged or colonizing form, and the sexual form. The leaf-gall insect produces from 500 to 600 eggs for each individual, the root-inhabiting insect not much above 100 eggs, the winged insect from 3 to 8, and the last or sexed insect but 1 egg. This last is the winter egg and may be taken as a starting point of the life cycle. It is laid in the fall on old wood, and hatches, the spring following, into a louse,

which goes at once to a young leaf, in the upper surface of which it plants its beak. The sucking and irritation soon cause a depression to form about the young louse, which grows into a gall projecting on the lower side of the leaf. In about fifteen days the louse becomes a plump, orange-yellow, full-grown, wingless female, and fills its gall with small yellow eggs, dying soon after. The eggs hatch in about eight days into young females again, like the parent, and migrate to all parts of the vine to form new galls. Six or seven generations of these wingless females follow one another throughout the summer, frequently completely studding the leaves with galls. With the approach of cold weather the young pass down the vines to the roots, where they remain dormant until spring. The root is then attacked and a series of subterranean generations of wingless females is developed. The root form differs but slightly from the inhabitant of the leaf galls, and the swellings or excrescences on the roots are analogous to those on the leaves.

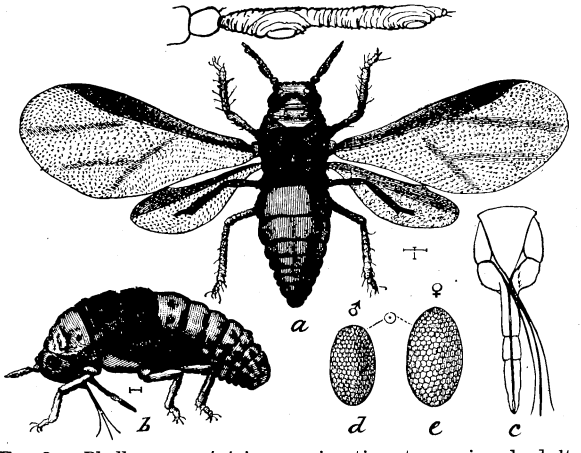

FIG. 3.—*Phylloxera vastatrix*. *a*, migrating stage, winged adult, *b*, pupa of same lateral view; *c*, mouth-parts with thread-like sucking setæ removed from sheath; *d* and *e*, eggs showing characteristic sculpturing—all enlarged (original).

During late summer and fall of the second year some of the root lice give rise to winged females which escape through cracks in the soil on warm bright days and fly to neighboring vines. These winged lice lay their eggs within a day or two in groups of two or four in cracks in the bark or beneath loose bark on the old wood of the vine and die soon after. The eggs are of two sizes, the smaller and fewer in number yielding males in nine or ten days, and the larger the females of the only sexed generation developed in the whole life round of the insect. In this last and sexed stage the mouth-parts of both sexes are rudimentary, and no food at all is taken. The insect is very minute and resembles the newly hatched louse of either the gall or the root form. The single egg of the larva-like female after fertilization rapidly increases in size until it fills the entire body of the mother and is laid within three or four days, bringing us back to the winter egg or starting point.

This two-year life round is not necessary to the existence of the species, and the root form may and usually does go on in successive

broods year after year, as in the case with European vines, on the leaves of which galls rarely occur. Under exceptional circumstances all of the different stages may be passed through in a single year. The young from leaf galls may also be easily colonized on the roots, and it is probable that the passage of the young from the leaves to the roots may take place at any time during the summer. The reverse of this process, or the migration of the young directly from the roots to the leaves, has never been observed.

The complicated details noted above were only obtained after years of painstaking research, conducted by the late Professor Riley in this country and many careful investigators in France.

Means of dispersion.—The distribution of phylloxera is, first, by means of the winged females; second, by the escape, usually in late summer, of the young root lice through cracks in the soil and their migration to neighboring plants; third, by the carrying of the young leaf-gall lice by winds or other agencies, such as birds or insects, to distant plants; fourth, by the shipping of infested rooted plants or cuttings with winter eggs. By the last means the phylloxera has gained a world-wide distribution; the others account for local increase.

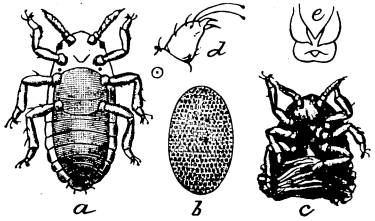

FIG. 4.—*Phylloxera vastatrix*. *a*, sexed stage-larviform female, the dark-colored area indicating the single egg; *b*, egg, showing the indistinct hexagonal sculpturing; *c*, shriveled female after oviposition; *d*, foot of same; *e*, rudimentary and functionless mouth-parts (original).

REMEDIES AND PREVENTIVES.

The enormous loss occasioned by this insect when it reached the wine districts of the Old World led to the most strenuous efforts to discover methods of control. Of the hundreds of measures devised few have been at all satisfactory in results. The more important ones are the use of bisulphide of carbon and submersion to destroy the root lice; and, as preventive measures, the use of resistant American stocks on which to graft varieties subject to phylloxera and the planting of vineyards in soil of almost pure sand.

Bisulphide of carbon.—The use of this liquid insecticide is practicable only in soils of such consistency as to hold the vapor until it acts on the root lice and yet friable enough to afford it enough penetration. It will not answer in compact clay soils, in very light sandy ones, or in soils liable to crack excessively. The liquid is commonly introduced into the soil by hand injectors at any season except that of blooming or of ripening of the fruit. Sometimes sulphuring plows are used, or the liquid is mixed with water and the soil about the vines thoroughly drenched. The great volatility of the bisulphide enables it to penetrate to the minutest roots, and the lice quickly perish. Four or five injections of one-fourth ounce each may be made to the

square yard over the entire surface of the vineyard, inserting the implement from 8 to 12 inches and not approaching within 1 foot of the base of the vine. The opening in the soil must be promptly closed with the foot. A large number of small doses is preferable to a few large ones. This treatment will ordinarily have to be repeated every year or two, and is therefore expensive and unsatisfactory and not to be recommended except where other means are not available.

Submersion.—Next to the use of resistant stocks, by far the best means against the phylloxera is in inundating vineyards at certain seasons of the year and for definite periods, being applicable wherever irrigation is practiced or water may be applied without too great expense. Submerging as a means against insects is a very ancient practice in southern Russia and in Greece, but was first used against phylloxera in 1868, in France, and is now practiced wherever feasible. The best results are obtained in soils which water will penetrate rather slowly. In loose and sandy soils submersion is impracticable. For this treatment vineyards are commonly divided into rectangular plats by embankments of earth, the latter protected from erosion by planting to some forage crop. As now practiced, the vines are inundated shortly after the fruit is gathered, when growth of the vines has ceased, but the phylloxera is still in full activity and much more readily destroyed than during the dormant winter season. The earlier the application the shorter the period required. During September from eight to fifteen days will suffice, and in October eighteen to twenty days, while if delayed until November a period of forty to sixty days will be needed. Copious irrigation at any time during the summer, if it can be continued for forty-eight hours, will give very considerable relief from phylloxera.

Planting in sand.—It was early observed that vines in very sandy soil were little subject to phylloxera injury, probably owing to the fact that the sand does not crack and allow the insects to escape and spread, being more thoroughly wetted with rains and subterranean moisture, and the insect is drowned out, as in submergence. The resistance is proportionate to the percentage of sand in the soil. In France vineyards are very successfully established on the sandy shores of the Mediterranean and in the alluvial sands of the valley of the Rhone and other streams.

American stocks.—The use of American vines, either direct for the production of fruit or as stocks on which to graft susceptible European and American varieties, has practically supplanted all other measures against phylloxera in most of the infested vineyards of the world. The immunity to root attack of American vines seems to be due to the thicker and denser bark covering of the roots and to greater natural vigor. All our vines are not equally resistant, and no vines are wholly immune, while several of our cultivated varieties,

as the Delaware, are almost as defenseless as European vines. Of the many wild American vines, those of chief importance as sources of stocks are the Æstivalis, Riparia, and Labrusca. Of these, Æstivalis and its cultivated varieties rank first in resistant qualities. The varieties of this species commonly grown and used for stocks are Herbemont and Cunningham. These are also very valuable on account of the superior quality of their own fruit.

The wild varieties of Riparia are quite resistant to the root louse, although the most subject of all vines to the attacks of the leaf-gall lice. Of the cultivated varieties, the Clinton, Taylor, Solonis, etc., are very commonly used as stocks. The fox grapes, derived from *Vitis labrusca*, while more resistant than European grapes, are much inferior to the other American species mentioned in this respect. Isabella and Catawba, for example, are very subject to root lice; the Concord, while not often seriously injured, is still rather subject to attack and therefore not so valuable as a source of resistant stocks. There are many hybrids of these and other American species, which are used either direct for their fruit or as stocks. Conditions of climate and soil will determine the particular variety to be employed, and these points can only be settled by experimental tests for new localities.

THE GRAPEVINE FIDIA.

(*Fidia viticida* Walsh.)

During midsummer the leaves of grapes are frequently riddled with irregular holes by the attacks of a little beetle which, when disturbed, falls to the ground with its legs folded up against its body, feigning death or "playing possum." The beetle is about a quarter of an inch long, rather robust, and of a brown color, somewhat whitened by a dense covering of yellowish-white hairs. In the nature and amount of the injury it does at this stage it resembles the rose-chafer, for which it is sometimes mistaken. Following the injury to the foliage, the vines may be expected, if the beetles have been abundant, to present a sickly appearance, with checking of growth and ultimate death, due to the feeding on the roots of the larvæ, for, as in the case of the phylloxera, the root injury is much more serious than the injury to foliage. Vines sometimes die after having developed half their leaves, or may survive until the fruit is nearly mature.

This insect occurs very generally in the Mississippi Valley States, from Dakota to Texas, and more rarely east of the Alleghanies and southward to Florida. The beetle has caused serious damage to foliage, notably in Missouri, Illinois, and Ohio, having been recognized over thirty years ago in the first-mentioned State as one of the worst enemies of the grape. The work of the larvæ has been recognized only recently by Mr. Webster and others in northern Ohio, but it may be looked for wherever the beetle occurs.

Life history.—The life history as worked out by Mr. Webster is briefly as follows: The yellowish eggs in large batches are thrust in cracks of the bark of the old wood, usually well above ground, as many as 700 having been counted on a single vine. Very rarely are they placed in cracks in the soil about the base of the vine, but so loosely are they attached to the bark that they not infrequently fall to the ground. The larvæ, on hatching, fall clumsily to the ground, and quickly disappear in cracks in the soil, chiefly near or just at the base of the vine. They feed at first on the fibrous roots near the point of entrance, but soon reach the larger roots, and completely denude them of bark, gradually extending outward through the soil

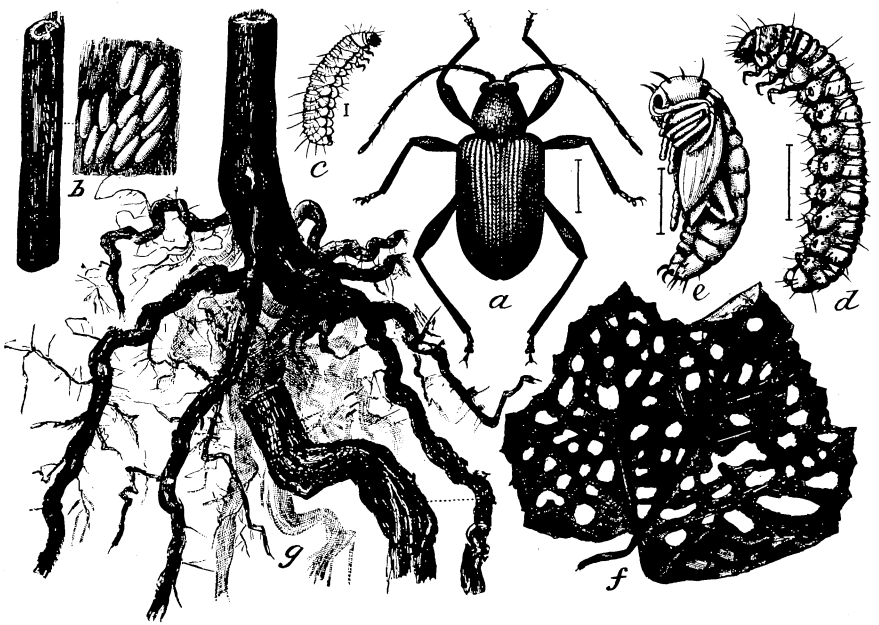

FIG. 5.—*Fidia viticida.* *a*, beetle; *b*, eggs represented natural size under fold of bark and much enlarged at side; *c*, young larva; *d*, full-grown larva; *e*, pupa; *f*, injury to leaf by beetles; *g*, injury to roots by larvæ—*b* (in part) and *f* and *g* natural size, rest much enlarged (original).

to a distance of at least 3 feet, and downward to a depth of at least 1 foot. Most of them reach full growth by the middle of August, attaining a length of nearly half an inch, and construct little cavities or earthen cells in the soil, in which they hibernate until June of the following year, when they change to pupæ.

The beetles emerge about two weeks after pupation, and begin to feed from the upper surface of the leaves. With thin-leafed grapes they eat the entire substance of the leaf, but with thick-leafed varieties the downy lower surface is left, giving the foliage a ragged, skeletonized look. They feed on any cultivated grape, also on the wild grapes, which have probably been their food from time immemorial.

Most of the adults disappear by the first of August, a few scattering individuals remaining until the first of September.

Remedies and preventives.—It is evident that if the beetle can be promptly exterminated the injury to the foliage will be limited, and the subsequent much greater damage by larvæ to the roots avoided. The first effort, therefore, should be to effect the killing of the beetles, which may be done by the use of an arsenical spray, with lime, applying it at the customary strength of 1 pound to 150 gallons of water. The feeding of the beetles on the upper surface of the leaves makes them especially easy to control by this means. If this be deferred until it is unsafe to apply an arsenical to the vines, the beetles may be collected and destroyed in the manner recommended for the rose-chafer. The larvæ may be destroyed about the roots by injections of bisulphide of carbon made in the way already described for the phylloxera. A safer remedy, and a very effective one if applied before the end of June or before the larvæ have scattered, is to wet the soil about the vines with a solution of kerosene emulsion. The emulsion should be diluted nine times, and a gallon or two of the mixture poured in a basin excavated about the base of the vine, washing it down to greater depths an hour afterwards with a copious watering.

THE GRAPE CANE-BORER.

(*Amphicerus bicaudatus* Say.)

The young shoots of the grape during the spring months in some districts will often be observed to suddenly break off or droop and die, and if examination be made a small hole will be found just above the base of the withered shoot, with a burrow leading from it a short distance into the main stem. Within the burrow will be found the culprit in the form of a peculiar cylindrical brown beetle about half an inch long. This beetle has long been known as the apple twig-borer, from its habit of boring into the smaller branches of the apple in the manner described for the grape. It also sometimes similarly attacks pear, peach, plum, forest and shade trees, and ornamental shrubs. To the grape, however, it is especially destructive, and the name "grape cane-borer" is now given to it as more appropriate. Much complaint of this beetle is always received during the winter and early spring. Frequently all the new growth is killed, and in some cases vines have been entirely destroyed. It is extremely common in the States bordering the Mississippi, from Iowa to Arkansas, and also in Texas, often becoming throughout this region the most important insect enemy of the vine. It also occurs eastward to the coast, but rarely causes much damage in its eastern range.

It breeds in dying wood, such as large prunings, diseased canes, and also in dying or drying wood of most shade and fruit trees. It has been found by the writer breeding very abundantly in roots of uprooted maples and in diseased tamarisk stems. In old, dry wood it

will not breed, so far as is known, nor in vigorous live growth, but seems to need the dying and partially drying conditions mentioned. The insect has but one brood yearly. The beetles mature for the most part in fall, and generally remain in their larval burrows until the following spring. A few may leave the burrows in the fall and construct others in the twigs of apple or other plants in which to hibernate. In the spring, however, they begin their destructive work early, burrowing into the axils of the grape and occasionally also into other plants. This is undoubtedly partly for food, but seems largely

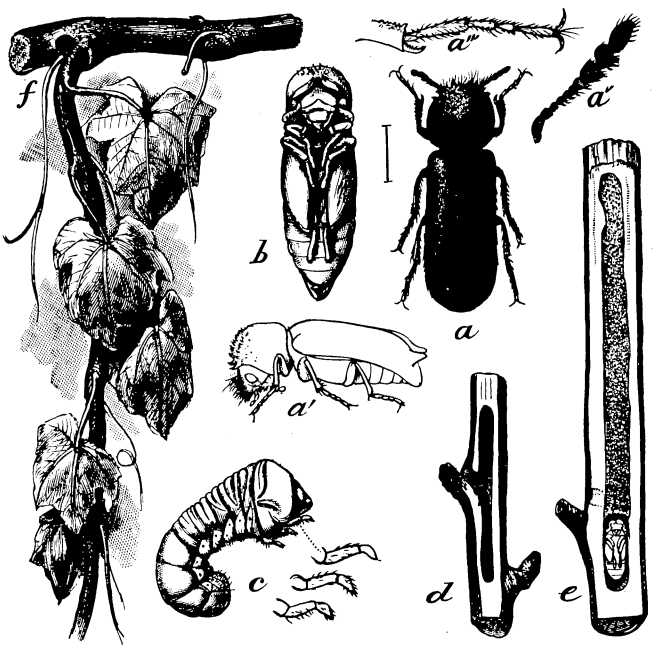

FIG. 6.—*Amphicerus bicaudatus*. *a*, beetle, dorsal and lateral view; *b*, pupa from beneath; *c*, larva from side, with enlargements of the thoracic feet; *d*, burrow in apple twig made by adult; *e*, larval gallery in tamarisk, with pupa in cell at end; *f*, injury to young shoot and cane, showing the entrance to burrow of beetle near *f* and the characteristic wilting of the new growth—all much enlarged except *d*, *e*, and *f* (original).

malicious, for it certainly has nothing to do with egg laying, although it may have some connection with the marital relation. The eggs are laid chiefly in May, or as early as March or April in its southern range, and the larvæ develop during summer, transforming to pupæ and beetles in the fall.

On the Pacific Coast a closely allied but somewhat larger species (*Amphicerus punctipennis* Lec.) breeds in grape canes and other plants, and probably has similar burrowing habits in the adult stage.

Remedies.—It will be apparent at once that to limit the work of this insect it will be necessary to promptly destroy all wood in which it will breed. This means the careful removal and burning of all dis-

eased wood and prunings at least by midsummer, thus destroying the material in which the larvæ are probably undergoing their development. If precautions of this sort are neglected and the beetle appears in the vineyard in spring, the only recourse is to cut out by hand every affected part and destroy the beetles. On warm days they may sometimes be collected in numbers while running about the vines.

THE GRAPEVINE FLEA-BEETLE.

(*Haltica chalybea* Ill.)

A little, robust, shining blue, or sometimes greenish, beetle, about one-fifth of an inch long, inclined to jump vigorously, and having greatly enlarged thighs, frequently appears on the vine in early spring, and bores into and scoops out the unopened buds, sometimes so com-

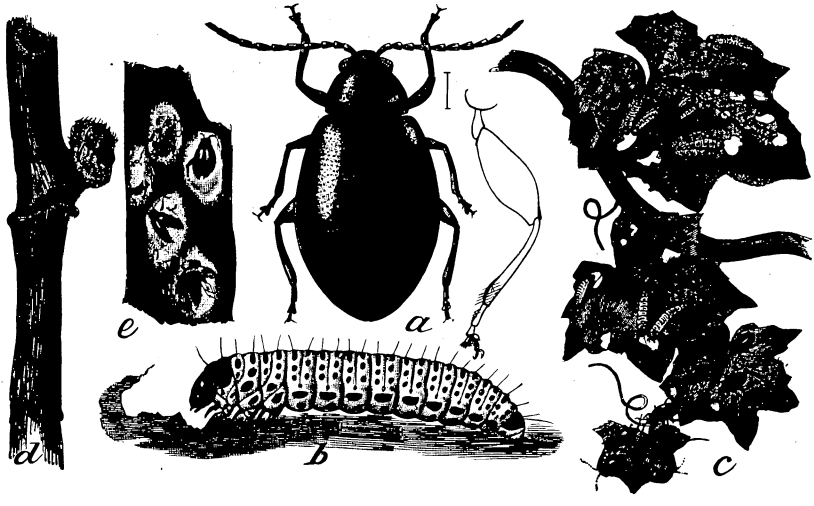

FIG. 7.—*Haltica chalybea*. *a*, beetle; *b*, larva; *c*, larvæ and beetles on foliage; *d*, injury to buds; *e*, beetles killed by fungus—*a* and *b* much enlarged, rest natural size (original).

pletely as to kill the vine to the roots. It attacks also the newly expanded leaves, filling them with small, roundish holes, and later deposits its orange eggs in clusters on their lower surface. Little shining brown larvæ come from these, which also feed on the leaves, and, if abundant, leave little but the larger veins. The larvæ are present for about a month during May and June, when they disappear into the ground, and transform to beetles during the latter part of June and in July. This second brood of beetles remain on the leaves through the summer, feeding a little, but doing but little damage to the vines, now in full leaf. In the fall the beetles go into winter quarters in any protection, as in cracks in fences or buildings, in masses of leaves, under bark, etc.

The grapevine flea-beetle is sometimes erroneously called thrips. It occurs throughout the United States and Canada, the time of its appearance varying with the latitude, and possibly being double-brooded in the South. It is often abundant on wild vines, and also occurs on the alder. In the spring it is, perhaps, the subject of more frequent complaint than any other grape insect.

The damage to the buds is most to be feared and the hardest to prevent. A very strong arsenical wash, say, 1 pound to 50 gallons of water, with lime, applied before or as soon as the beetles appear, will, perhaps, afford protection. Mr. Howard has found also that the beetles at this season may be successfully jarred into cloth collecting frames placed about the vines as recommended for the rose-chafer, and that if the cloth is saturated with kerosene, the beetles striking it will soon perish. Later in the season the beetles and larvæ on the foliage may be reached by an arsenical spray of the customary strength, viz, 1 pound of the poison to 150 gallons of water.

THE ROSE-CHAFER.

(*Macrodactylus subspinosus* Fabr.)

With the blooming of the grape, an awkward, long-legged, light-brown beetle about one-third of an inch in length frequently appears in enormous swarms, at first devouring the blossoms, then the leaves, reducing them frequently to mere skeletons, and later attacking the young fruit. By the end of July these unwelcome visitors disappear as suddenly as they come.

Though now distinctively a grape pest, it was first known as an enemy of the rose, whence its name, "rose-bug," or rose-chafer. It attacks also the blossoms of all other fruit trees and of many ornamental trees and shrubs, and, in fact, in periods of great abundance, stops at nothing—garden vegetables, grasses, cereals, or any green thing. At such times plants appear a living mass of sprawling beetles clustering on every leaf, blossom, or fruit.

The rose-chafer occurs from Canada southward to Virginia and Tennessee, and westward to Colorado, but is particularly destructive in the eastern and central portions of its range, notably in New Jersey, Delaware, and to a less extent in New England and the Central States.

It passes its early stages in grass or meadow land, especially if sandy—the larvæ feeding on the roots of grasses a few inches below the surface of the ground like the common white grub, which they closely resemble except in size. The eggs are laid in the ground in June and July, and the larvæ become full grown by autumn and transform to pupæ the following spring, from two to four weeks prior to the emergence of the beetles.

Remedies.—The rose-chafer is a most difficult insect to control or destroy, and the enormous swarms in which it sometimes appears make the killing of a few thousand or even millions of little practical

value. Practically all substances applied to vines to render them obnoxious to the beetles have proved of little value, but a correspondent reports having successfully protected his vineyard last summer by spraying with a wash made by diluting 1 gallon of crude carbolic acid in 100 gallons of water. The arsenicals are available only when the beetles are not very numerous; otherwise their ranks are constantly recruited by newcomers, and under these circumstances all insecticides, however effective ordinarily, are unavailable. When this is the case, the only hope is in collecting the beetles or in covering and protecting plants with netting, or later in bagging grapes. Advantage may be taken of their great fondness for the bloom of spiræa,

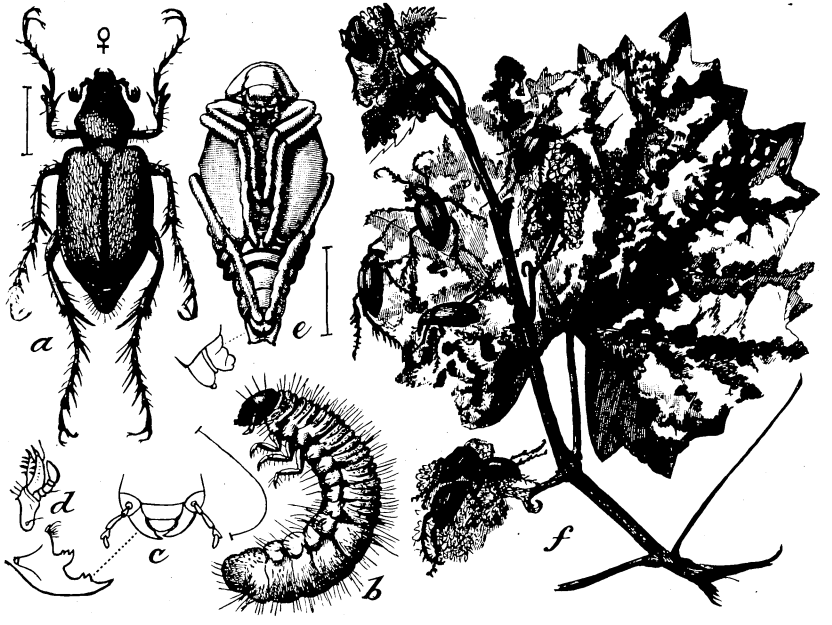

FIG. 8.—*Macrodactylus subspinosus.* *a*, beetle; *b*, larva; *c* and *d*, mouth-parts of same; *e*, pupa; *f*, injury to leaves and blossoms with beetles, natural size, at work (original).

and rows of these flowering shrubs may be planted about the vineyard to lure them and facilitate their collection.

They may be gathered from these trap plants, or the grapes themselves, in large hand beating nets, or by jarring into large funnel-shaped collectors on the plan of an inverted umbrella. The latter apparatus should have a vessel containing kerosene and water at the bottom to wet and kill the beetles.

All measures must be kept up unceasingly if any benefit is to be derived.

The numbers of the rose-chafers may be considerably limited by restricting the areas in which they may breed. All sandy meadow

land especially should be broken up and cultivated to annual crops, and the more general the cultivation of all lands the fewer will be the rose-chafers. In this procedure notable results may only be secured by the cooperation of a neighborhood.

THE GRAPE LEAF-FOLDER.

(*Desmia maculalis* Westw.)

One of the noticeable features of a vineyard, particularly in midsummer and later, is the many folded leaves the interiors of which have been skeletonized. This is especially evident with thick-leafed varieties, the whitish under surface contrasting strongly with the dark green of the upper. If the leaf be unfolded, it will be found to contain a very active, wriggling, greenish larva, a little less than an inch long, which is apt to spring out of the fold and fall, or hang by a thread. The leaf itself will be found to be attached to the folded part by means of numerous little cords of silk. If the larva is full grown, the interior of the leaf will be thoroughly skeletonized, and soiled with accumulated excrements. The fold almost invariably brings the upper sides of the leaf together, the larva feeding, therefore, on what would be the upper surface of the leaf. The larva transforms to a reddish-brown chrysalis usually within a much smaller fold of the edge of the leaf, but sometimes within the larger larval fold. The moth, which, during midsummer, issues in a few days, expands about an inch and is a shining opalescent black, with wings bordered with white and marked with white spots, as in the illustration (fig. 9), a slight variation in maculation being noted between the males and females. The moth is seldom seen, but if the vines be shaken it may be frightened up and observed in quick flight seeking other concealment. There are two, or, in the South, three, broods each summer, the last brood hibernating in the leaves very much as does the grape-berry moth, the pupal cases of which are very similar to those of the leaf-folder. It occurs from New England southward to Florida, and westward at least to the Rocky Mountains, and probably is distributed throughout the vine districts of the United States. It affects all kinds of grapes, showing, perhaps, a little preference for the thick-leafed over the thin-leafed varieties.

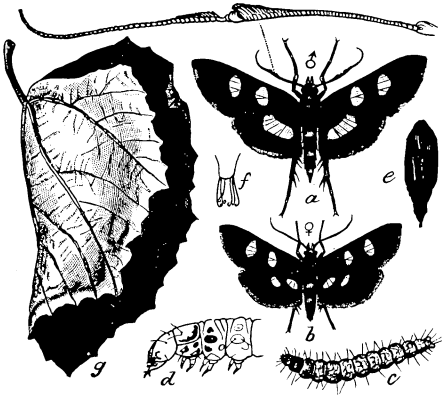

FIG. 9.—*Desmia maculalis*. *a*, male moth; *b*, female; *c*, larva; *d*, head and thoracic segment of same, enlarged; *e*, pupa; *f*, tip of pupa, enlarged; *g*, grape leaf folded by larva (original).

Remedies.—The appearance of a leaf folded by a larva of this insect renders its detection easy, and if the vines are gone over and the larvæ crushed in the folded leaves early in the season when they are few in number, allowing none to escape, later damage may be almost entirely prevented. If the vines are sprayed with arsenicals for other leaf-eating insects, the treatment will destroy all larvæ folding leaves soon thereafter, but not those already present. The ease with which

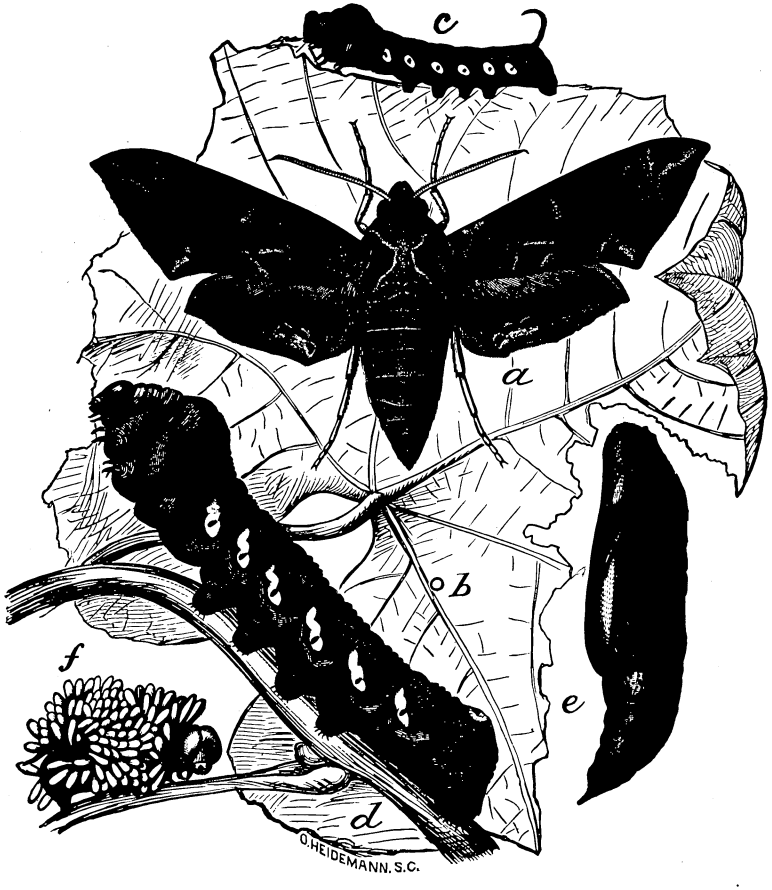

FIG. 10.—*Philampelus achemon.* *a*, moth; *b*, egg; *c*, young larva; *d*, mature larva; *e*, pupa; *f*, parasitized larva—all natural size (original).

this insect may be destroyed by hand makes it hardly advisable to spray for it alone, and after the grapes have become well formed later in the summer it is no longer safe to spray with arsenicals. Aside from hand picking at this time there is nothing to be done except to adopt measures which will afford protection the following year. These consist in the collection and burning of all fallen foliage as promptly as possible in autumn to destroy the hibernating larvæ and chrysalides.

HAWK MOTHS AND CUTWORMS.

The larvæ of upward of 50 moths feed on the foliage of the grape. Many of these are rare, yet many others are occasionally destructive. Aside from the leaf-folder already discussed, perhaps the leaf-feeding caterpillars oftenest the cause of important damage are the large green or brownish, usually horned, sphingid larvæ and certain cutworms.

Hawk moths.—The larvæ of some ten species of hawk moths or sphingids occur on the grape, and nearly all are widely distributed. The one most frequently met with is the Achemon sphinx (*Philampelus achemon* Drury) herewith figured (**fig. 10**) to illustrate the characteristics of the group. The sphinx larvæ strip a branch at a time completely, and are, therefore, easily noted. They are not often very abundant and the injury is not usually great, except in the case of young vines, which may be entirely stripped and killed by a single larva. Hand picking is ordinarily the simplest and most satisfactory remedy.

Cutworms.—The climbing cutworms have at times proved very destructive to the buds and foliage of vines, and in northern New York, and particularly in the raisin district of Fresno County, Cal., as much damage has been done by them as by any other insect enemy.

Of the several species which in different localities have been troublesome, the worst record may be assigned to the dark-sided cutworm (*Agrotis messoria* Harr.) and the variegated cutworm (*A. saucia* Hbn.), both occurring throughout the United States, and the ones chiefly concerned in the region noted in California. Cutworms remain concealed in the ground during the day and climb up and strip the vines at night. They may be easily destroyed by the use of a poisoned bait of bran, arsenic (or paris green), and water, preferably sweetened with a little sugar. It should be distributed about the base of each vine in the form of a mash, a handful or so in a place.

THE GRAPE LEAF-HOPPER.

(*Typhlocyba vitifex* Fitch.)

From midsummer to autumn, in increasing amount, the leaves of grapes are affected by a little jumping insect commonly known as the thrips, or leaf-hopper, which works in enormous numbers on the underside of leaves, causing them to appear blotched and scorched or covered with little yellowish or brownish patches, and eventually dry up, curl, and fall. This insect occurs with great regularity wherever the vine is cultivated, and yet so gradually is the damage done that, notwithstanding the great annual loss that must result to grape growers from this insect, no particular effort is ordinarily made to remedy the evil.

The depredator is a very minute insect, not exceeding one-eighth of an inch in length, and has a peculiar habit of running sidewise when

disturbed, like a crab, and dodging from one side of the leaf to the other. It jumps vigorously, like a flea, but also takes flight, rising in swarms when the vines are shaken. If examined without being too much disturbed, they will be noticed thickly clustered over the undersurface of the leaves, busily engaged in sucking the juices of the plant.

Under a lens they will be found to vary considerably in color, and, in fact, they are supposed to represent a large number of distinct species, all closely allied, however, and possessing identical habits. The prevailing color is light yellowish green, with the back and wings variously ornamented with red, yellow, and brown. In the fall they become much darker, though retaining the wing patterns. In any vineyard usually one-half dozen or more color species will occur together, one or two of which will predominate, while only a few miles distant some other forms will be the common ones. The insect figured

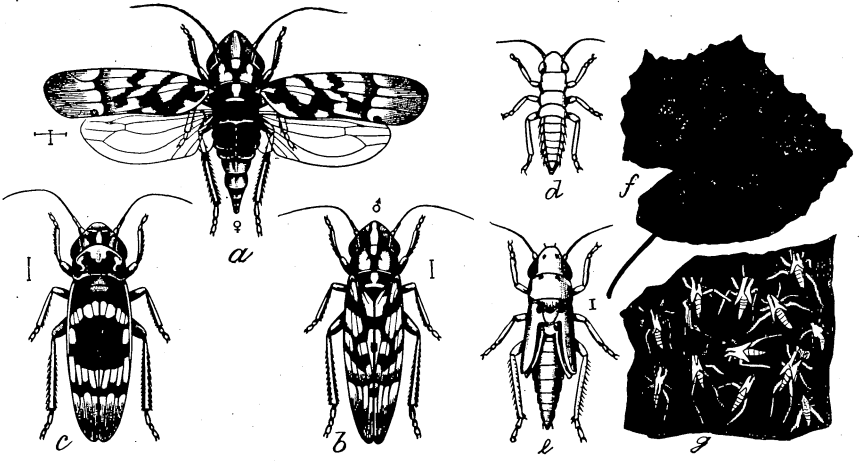

FIG. 11.—*Typhlocyba* spp. *a*, *T. comes* Say, female; *b*, *T. comes* Say, male; *c*, typical form of *T. vitifex*; *d*, larva; *e*, pupa; *f*, appearance of injured leaf; *g*, cast pupal skins (original).

(fig. 11) represents the most abundant species on the grounds of the Department of Agriculture in the summer of 1895, together with Fitch's original type at the right.

They begin to appear on the vines in June, and gradually increase in numbers through July, August, and September, remaining on the vines until the leaves fall, and afterwards may be frightened up in swarms from masses of leaves about the vines. The winter is passed wherever protection may be secured from storms, particularly in masses of accumulated leaves, and especially where these have been blown up against logs or fences. In such situations the writer has observed them by thousands on warm days in early winter. All varieties of grapes are attacked, the thin-leafed sorts most injuriously, but vast injury is done to all, including the wild grapes, and at least one other wild plant—the redbud or *Cercis canadensis*.

Life history.—The eggs are thrust by the female singly into the substance of the leaf on the lower side, either into the midribs and large veins or in the intervening spaces. The young are much like the adults, except that they are smaller and wingless. They cast their skins three times before becoming full grown and acquiring wings, and the white cast skins remain attached to the undersurface of the leaves, frequently upward of 100 clinging to a single leaf. In the middle and southern portions of their range they undoubtedly pass through 4 or 5 broods annually, the life of a single generation probably covering about a month.

Remedies.—The prevention of injury by the leaf-hopper is a very difficult problem. The best chances of relief will come from taking advantage of its hibernating habit and collecting and burning all fallen leaves and any similar material about the vineyards which would furnish it with winter quarters. This will be effective in proportion to the thoroughness with which it is carried out, and the treatment must be extended over a considerable area to give much relief. In this connection it must be remembered that the leaf-hoppers coming from wild grapes or from near-by vineyards are particularly apt to hibernate in woods, returning to the vineyards again the following spring.

Direct measures against this insect consist in spraying with kerosene emulsion or the use of tarred or kerosene shields. The great activity of the insect makes spraying under ordinary circumstances with caustic washes somewhat ineffective, but if the application be made in the early morning or late evening, especially if a cold or moist day be chosen, when the insects are somewhat torpid, considerable benefit will result. The emulsion should be diluted with nine parts water. Applied under the circumstances described, a great many of the leaf-hoppers will be wet with the emulsion or will fly back to the leaves and get it on their bodies before it will have evaporated. The shield method should be used in the warm part of the day, when the insects are most active. A frame with cloth stretched over it and saturated with kerosene or diluted tar may be carried along between the vine rows, the vines being agitated at the same time. The insects will fly up, and all of those striking against the screen will either adhere to the tar or get wet with the kerosene and perish. The shield method, to be effective, must be continued every day or two until relief is gained.

THE GRAPE-BERRY MOTH.

(*Eudemis botrana* Schiff.)

As the grape berries become full grown and begin to ripen, often many of them will be observed to be discolored, and if these be examined a burrow will be found eaten through the pulp from the discolored spot, and within it a whitish larva. These injured berries begin

to appear while the fruit is young and green, and as it ripens they increase in number. Frequently several of these discolored and shriveled berries will be fastened together by silken threads intermixed with the excrement of the larvæ and the sticky grape juice, the larva having passed from one to another. The appearance is not unlike that produced by black rot, and is often confused with the latter. As the larva becomes mature it changes to an olive-green or dark-brown color, and not only excavates the pulp, but burrows into the seeds of the grape. It is very active and is apt to wriggle out of the grape and escape. When full grown, the larva attains a length of about one-third of an inch, and, abandoning the grape, cuts out of a grape leaf a little flap, which it folds over and fastens with silk, forming a little oblong case, in which it changes to a chrysalis. The little slate-colored moth with reddish-brown markings on the forewings appears in ten or twelve days, drawing its chrysalis partly

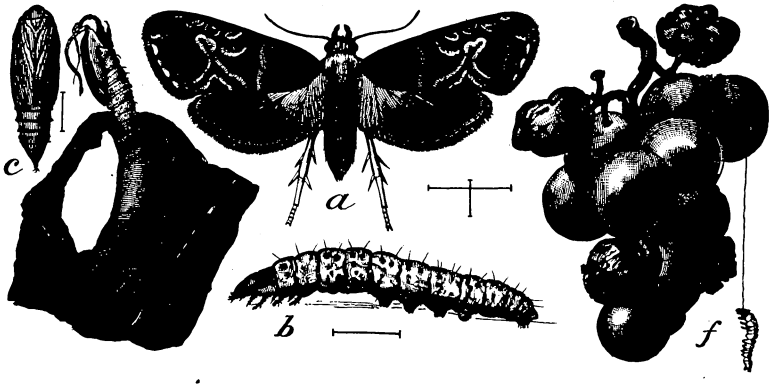

FIG. 12.—*Eudemis botrana*. *a*, moth; *b*, larva; *c*, pupa; *d*, folded leaf with pupa shell projecting from case cut from the leaf; *f*, grapes, showing injury and suspended larva, natural size—all except *f* much enlarged (original).

after it and depositing eggs for an additional brood of larvæ. The last brood of larvæ remains in the leaf cases through the winter. The moths coming from these hibernating chrysalides appear in early spring, and the first brood of larvæ lives on the leaves, tendrils, and blossoms, there being, of course, no grapes for them to infest.

This insect was imported many years ago into this country from southern Europe, where, in Austria and Italy particularly, it is very injurious and has two or three near allies which affect grape leaves and fruit in the same way, but which, fortunately, have not, as yet, been imported into this country, or if so, have not become numerous enough to be recognized. Our grape berry moth is widely distributed, occurring probably wherever the grape is grown to any extent, from Canada to Florida and westward to California. It attacks all varieties, but is especially destructive to grapes with tender skins and such as grow in compact bunches. The records of the Department

show also that this insect is a rather general feeder, and it has been bred from seed bunches of sumac and the leaves of tulip and magnolia. It sometimes enters the leaf galls of the phylloxera and eats not only the interior of the galls, but, as observed by Mr. Pergande, the young and mother louse also. It has proved particularly destructive at times in Ohio, Missouri, and Pennsylvania, and in many cases from 50 to 75 per cent of the crop has been ruined by it. It is probably three-brooded, except in its more northern range, the first brood developing on the leaves in May and June, the second brood on green grapes in July, and the third brood on ripening grapes in August and September. The early brood of this insect is so scanty that it is rarely noticed, and hence protective steps are seldom taken. Later in the season it multiplies with great rapidity, and particularly does it become numerous and destructive if grape gathering be deferred until a late period.

Remedies.—The use of poisons is not practicable except against the first brood, which develops on the green parts of the vine, and here the result is doubtful, because it is more than likely to breed on a great variety of foliage, and spraying would not afford much protection. Bagging the grapes as soon as the fruit sets will undoubtedly protect them from this insect, and at the same time from black rot. Of greater practical value, especially in larger vineyards, is the prompt collection and burning of all fallen leaves in autumn, thus destroying the hibernating larvæ and pupæ, and also the collection and destruction of diseased fruit wherever feasible. Early gathering and shipping or disposal of fruit otherwise is a particularly valuable step, as it insures the removal of the larvæ in the grapes from the vineyard if not their destruction in wine making. All fallen fruit should also be gathered and destroyed.

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